Placing Environmental Lead Exposure on Notice

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Outline

- Overview of basic epidemiology & theory guiding this work

- Working Examples
  - Lead exposure and crimes in St. Louis, Missouri, USA
  - Lead exposure and sexually transmitted infections in St. Louis, Missouri, USA

What is Epidemiology?

I keep six honest serving-men

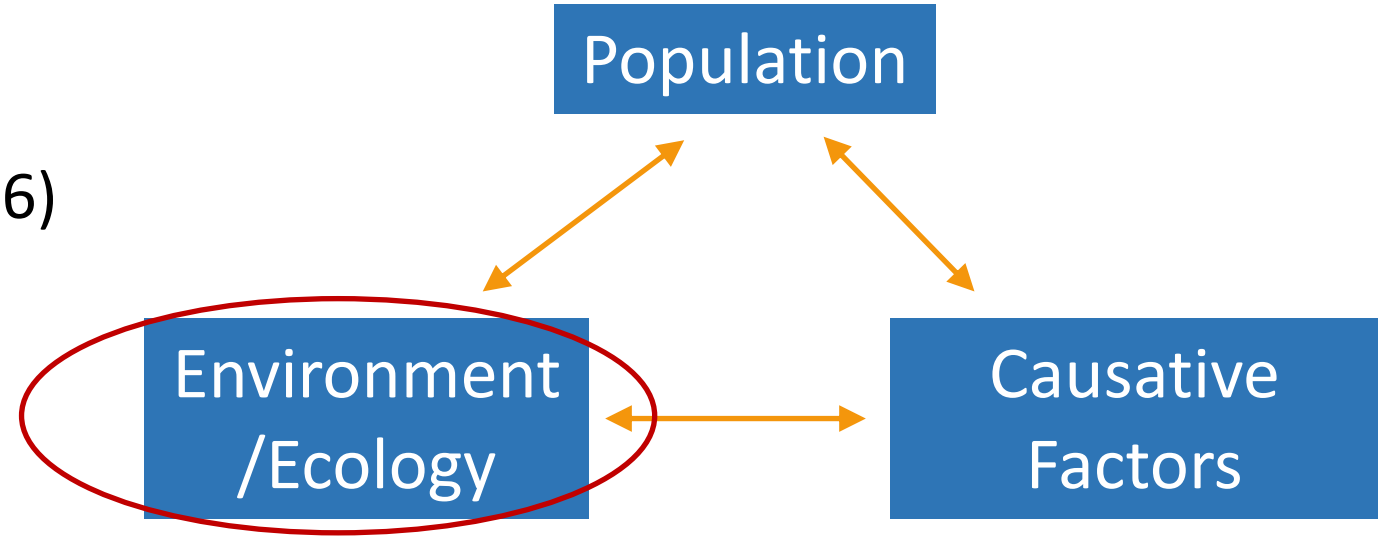
(They taught me all I knew);

Their names are **What** and **Why** and **When**

And **How** and **Where** and **Who**.

-Rudyard Kipling (1865-1936)

Epidemiologic Triangle



Kipling, R. Just-So Stories: The Elephant's Child, 1902. Reprinted by Everyman's Library Children's Classics. New York, Alfred A Knopf, 1992, p 79.

Key Concepts of Epidemiology

- Health and disease are not randomly distributed

- Disease causation in multifactorial

- Health inequalities or health inequities
  - Systematic and preventable

Social Determinants of Health

"Conditions in the environments in which people are born, live, work, play, worship, and age that affect a wide range of health, functioning and quality-of-life outcomes and risks"

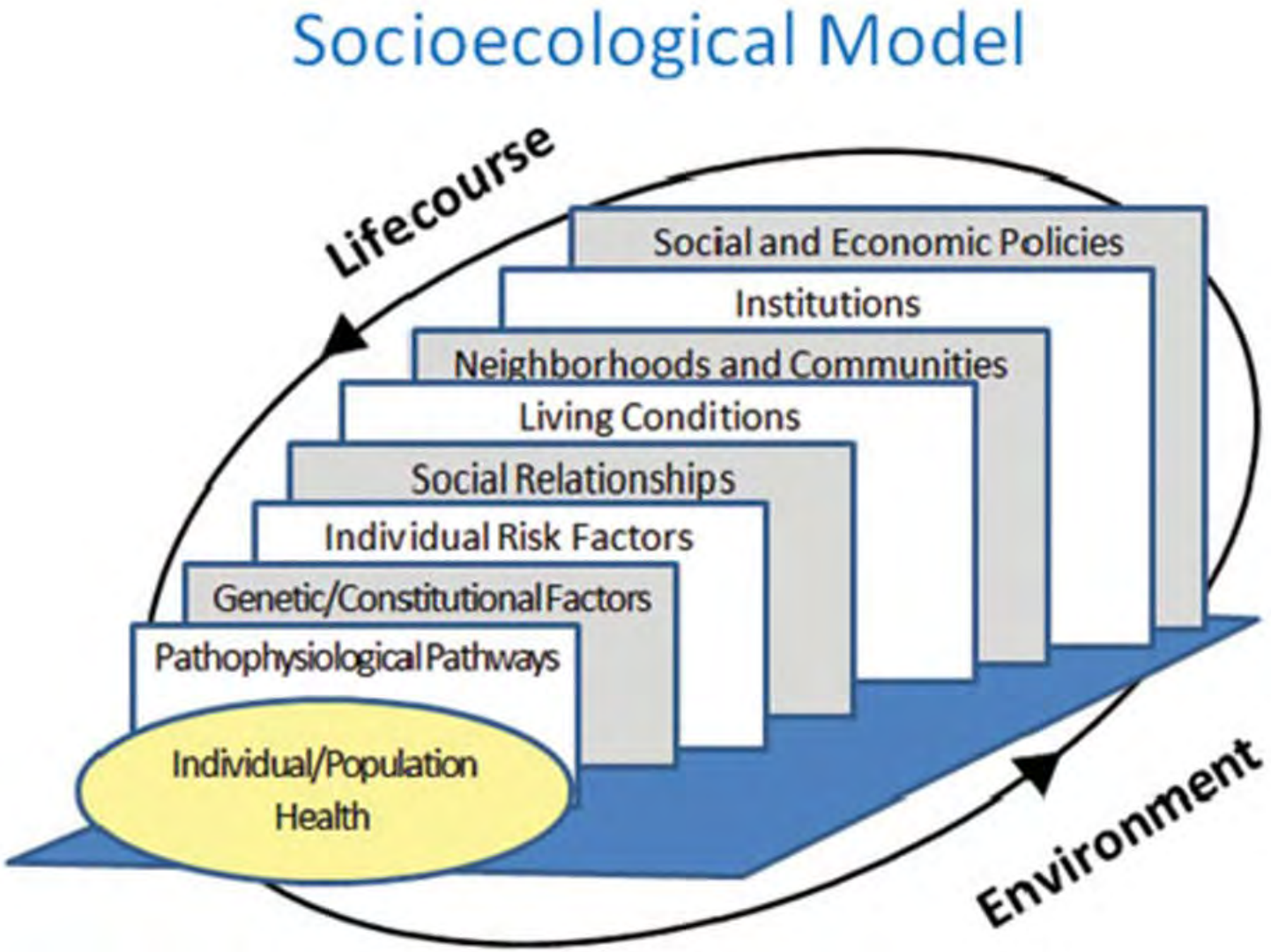
- Healthy People 2020

Determinants of Health

The World Health Organization defines social determinants of health as the conditions in which people are born, grow, work, live and age, and the wider set of forces and systems shaping the conditions of daily life.[1] While not a complete list, the AHA has identified the following social determinants of health:

- **Economic Stability:** Food security, housing, employment and income/poverty level
- **Neighborhood and Built Environment:** Quality of housing, food access, violence, crime/public safety, environment (clean water and air or pollution), healthy workplaces, schools and transportation
- **Education:** Language and literacy, educational attainment and early childhood development
- **Social and Community Context:** Social support, social cohesion, civic engagement, faith-based communities and incarceration
- **Health and Health Care:** Access to primary, specialty and emergency care, affordability, health literacy, quality of care and insurance coverage
- **Biology:** Genetics, race/ethnicity, gender identity and sexual orientation
- **Health Behavior:** Personal health practices and behaviors (eating, exercise, sexual practices, etc.)

Social-Ecological Model



So what do we usually do in research?

INFORMATION

Demographics
Behaviors
Social Norms
Substance Use
Etc.

Worlds apart

Two communities that are both situated within the Indianapolis metropolitan area and separated by only 28 miles are in reality worlds apart. One sits in a northeastern suburb of Indianapolis. Its residents have a life expectancy of 83.7 years, rivaling the top-ranking countries of the world, Switzerland (83 years) and Japan (84 years). Taking a drive from that community along I-465 and I-70 into the city, life expectancy drops off – to 78.9 years, then to 74.2 years - until you arrive in the second community, situated within the urban core directly south of Monument Circle. Its residents have a life expectancy of 69.4 years, similar to countries like Uzbekistan (69 years), Bangladesh (70 years), and Iraq (70 years).

http://www.savi.org/savi/documents/Worlds_Apart_Gaps_in_Life_Expectancy.pdf

Disease Landscape

$$Genotype * Environment = Phenotype$$

Minimal change in last 100 years

Large changes in last 100 years

Unhealthy gene expression

Place Matters

CEBP FOCUS

The New Vital Sign: Where Do You Live?

Electra D. Paskett

In all of these situations, the impact of living in unfavorable geospatial factors is the same: poorer cancer outcomes. Moreover, residence is a marker for poorer adherence to medical advice. For example, those who live in poorer areas are less likely to stop smoking (4, 5) and find it harder to travel to a quality facility for a screening test (6). Thus, where one lives is a risk factor for disease and mortality above the usual risk factors.

Working Example

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The intersection of aggregate-level lead exposure and crime

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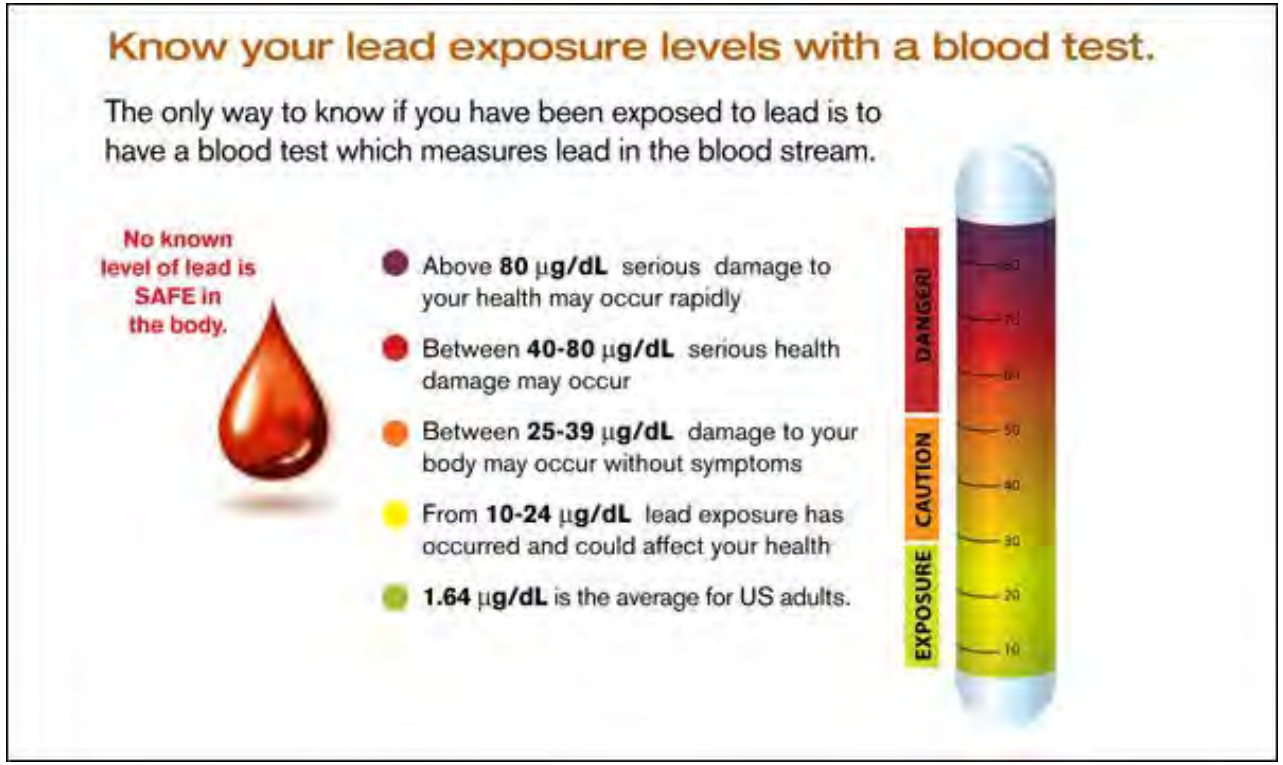
Sources of Lead (in the U.S.)

- Lead paint (Banned in 1978)
- Water
- Work Exposure
- Gasoline (not anymore)
- Imported candies (mostly from Mexico and Asia)
- Art supplies
- Contaminated soil
- Jewelry
- Dishes
- Mini-blinds
- Lunchboxes made of vinyl

Elevated Blood Lead Levels (EBLLs)

- 2007-2010: 535,000 (2.6%) kids ages 1-5 years have EBLL
- 1997-2001: >80% of kids with EBLL were of minority race/ethnicity
- Higher among people in substandard housing ~ disadvantaged individuals (6% of *poor kids* and only 0.5% of *wealthy kids with EBLLs)*
- Blacks are 3x more likely to have EBLL than whites



There is no safe level of exposure

Exposure in children

- Learning disabilities (lower intelligence)
- Attention deficit disorders (ADD)
- Behavior issues
- Nervous system damage
- Speech and language impairment
- Decreased muscle growth
- Decreased bone growth
- Kidney damage

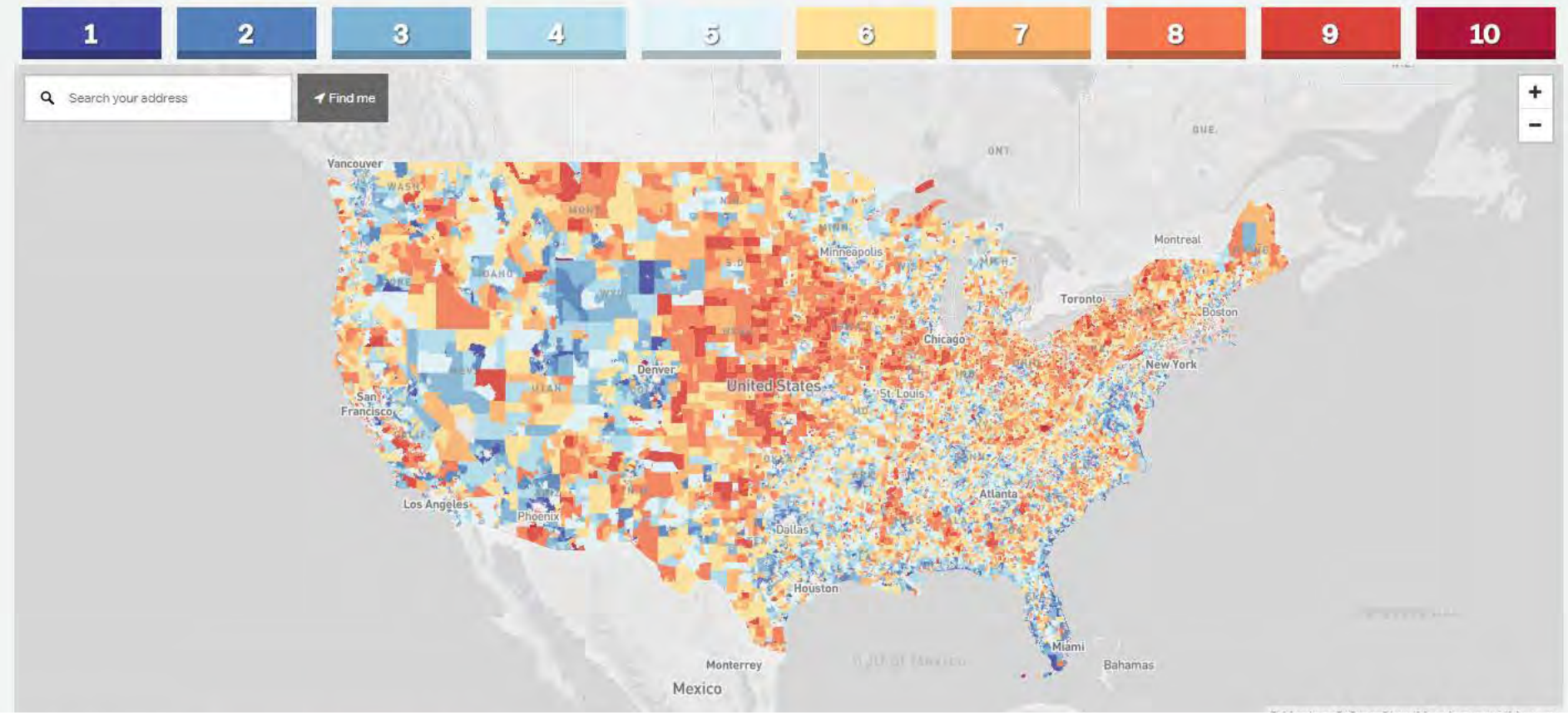
Exposure in Adults

- Illness during pregnancy
- Harm to fetus (brain damage, death)
- Fertility problems in men and women
- High blood pressure
- Digestive issues
- Nerve disorders
- Memory and concentration problems
- Muscle and joint pain

*High levels of exposure – seizures, unconsciousness, death

Geographical Variation of Exposure

- http://www.vox.com/a/lead-exposure-risk-map



Primary Research QuestionS

- What is the geographic relationship between aggregate blood lead levels and aggregate crime?

- Are there differences between violent AND non-violent crimes?

Lead Exposure Data

- Blood lead tests performed by Missouri Dept of Health and Senior Services from 1996 to 2007 (n=59,645)
- Venous tests (capillary if all that was available)
- Children <72 months old
- Not random, screening rates varied by year (44.2% screened in 2007)
- Pattern of testing and # of elevated blood tests were consistent across years of the data
- Note: used highest measurement for households with multiple measures on same day

Crime Measurement

- Federal Bureau of Investigation's Unified Crime Report 2010-2012
  - St. Louis Metropolitan Police Department
- 90,433 locations where crimes occurred (95% of all crimes geocoded)
- Classified as violent (n=15,734) or non-violent (74,699)

Other Covariates

- Concentrated Disadvantage
  - Principal Components analysis of 7 variables from US Census
  - Factor explained 75.5% of variance of 7 variables
  - Standardized and weighted for use in regression

- Interaction term
  - Concentrated Disadvantage * Elevated Blood Lead Levels

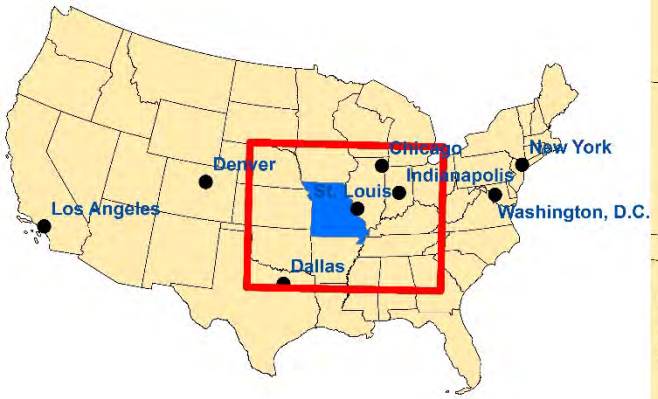
METHODS: Areal-based Models

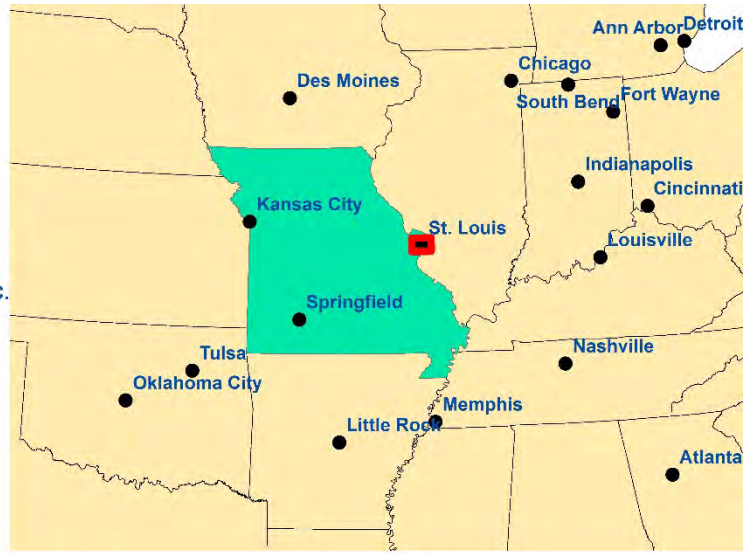
- Focus on polygons and their adjacency
- Public health policies often are made at the state, county, city levels
- Can readily incorporate other data sources
- Easy to communicate findings (usually with a map)

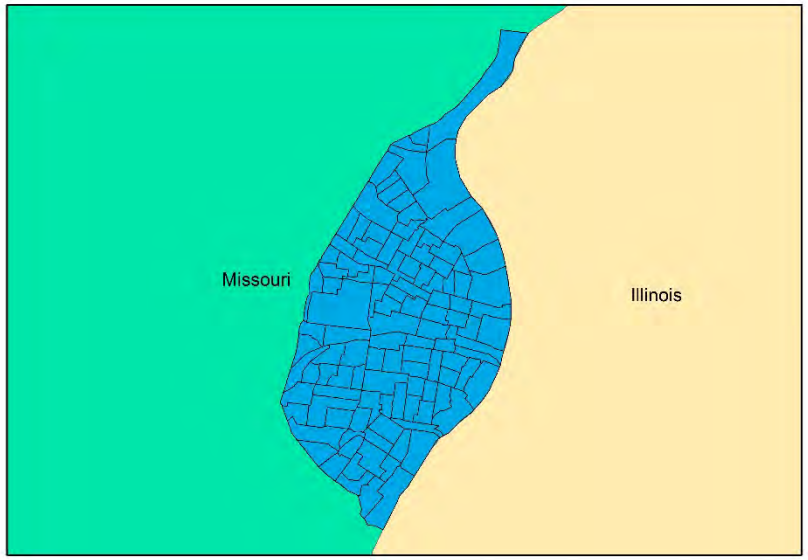
Spatial Regression

- Spatial autoregressive model
  - Structured Autoregressive (STAR) Model via BayesX (accessed through R)
  - Assumes a Poisson distribution
  - Accounts for spatial autocorrelation (spatial adjacency) via random effect
  - Accounts for spatial autocorrelation and covariates simultaneously
  - Uses Markov Chain Monte Carlo simulation to estimate parameters
  - Provides adjusted estimates of risk

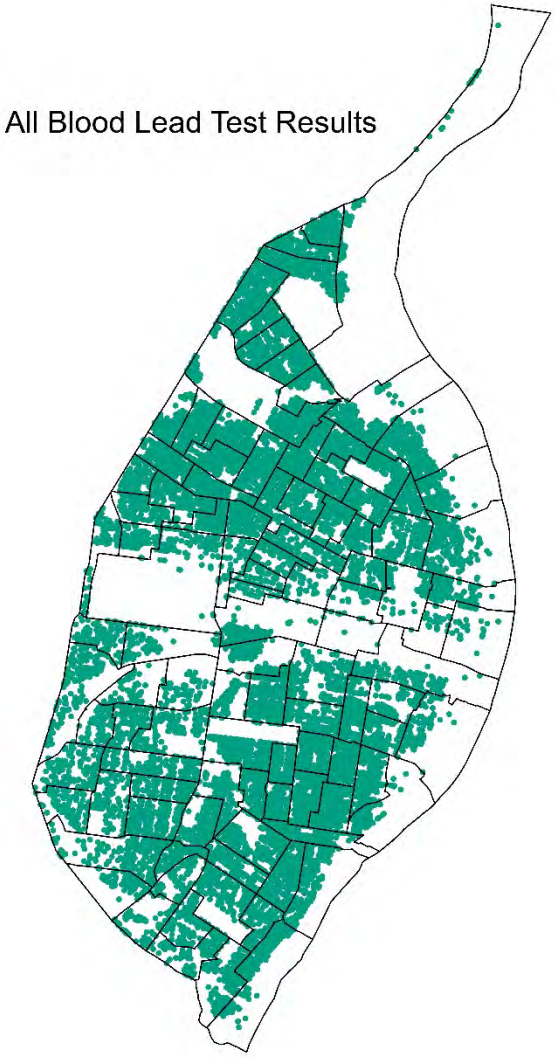
Study Area: St. Louis City County, MO

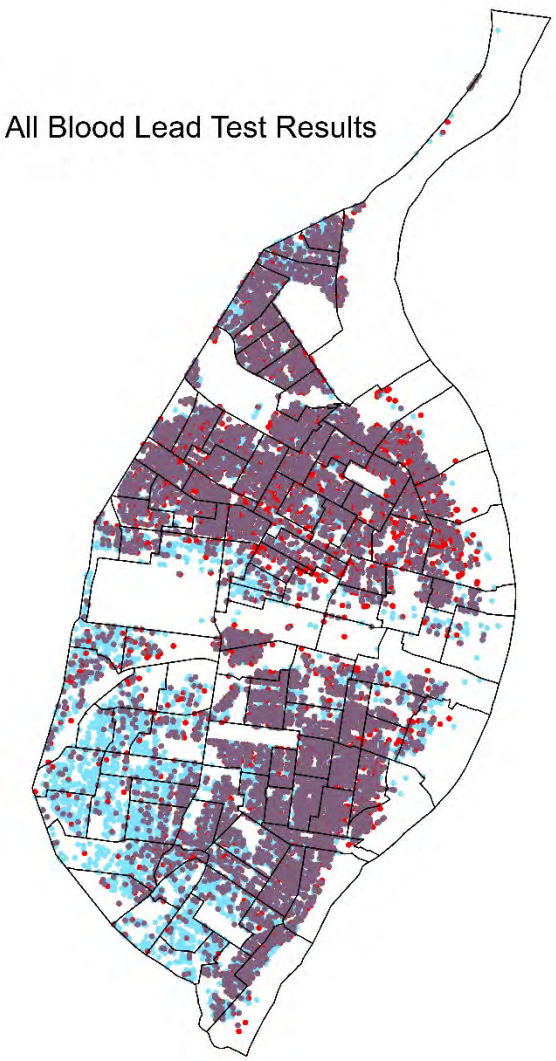


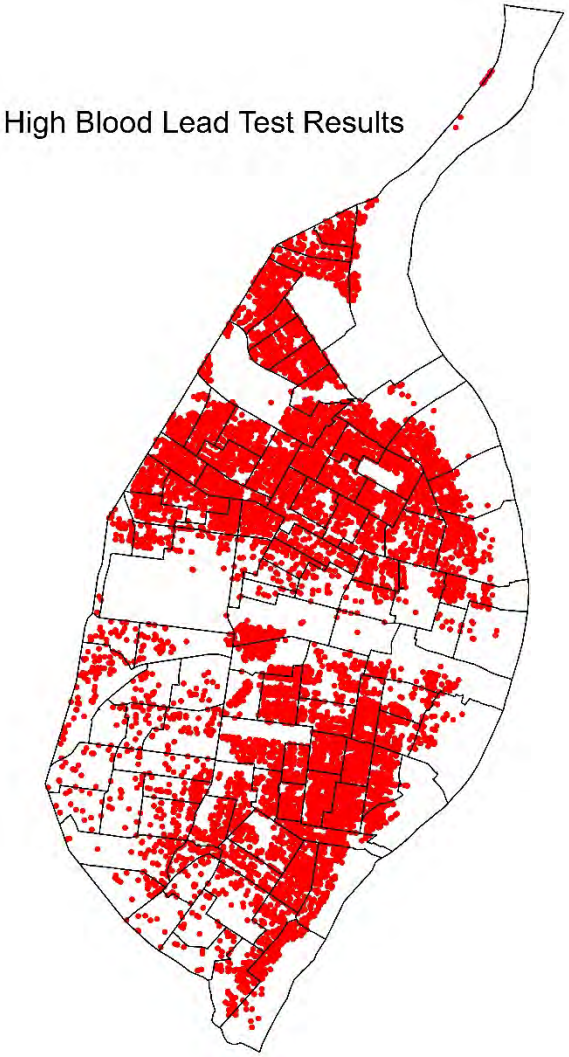


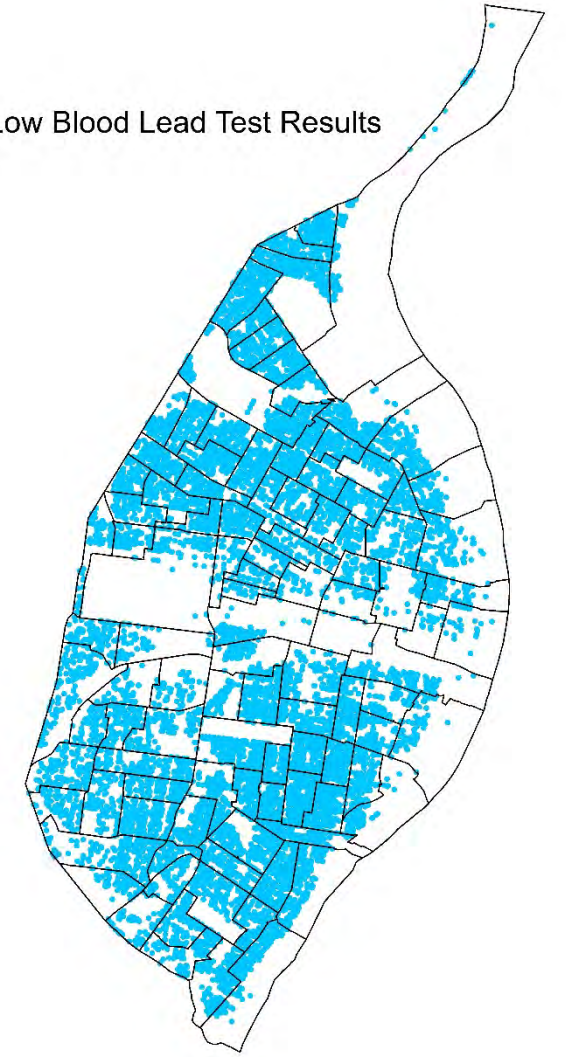


Geographic Distribution - Lead

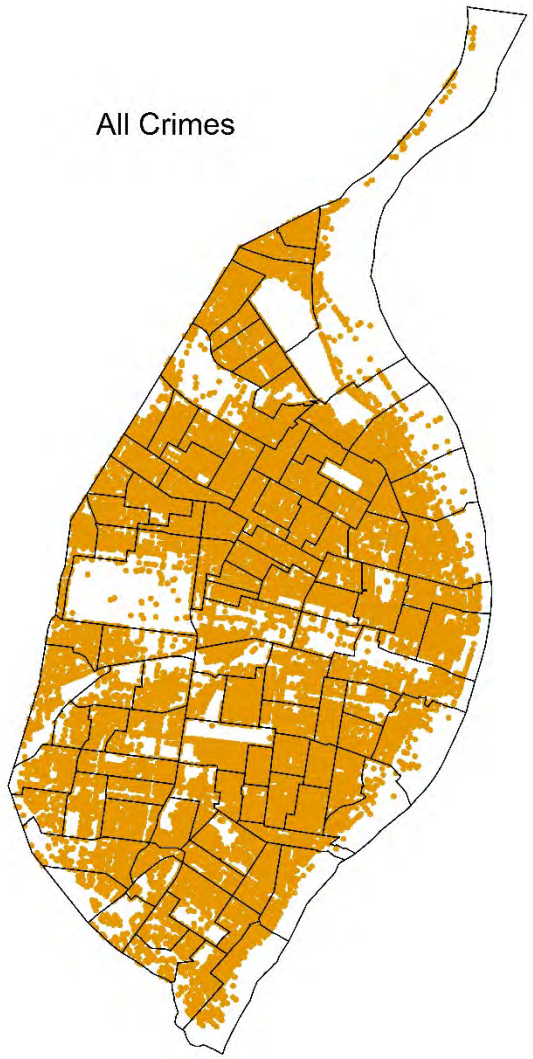


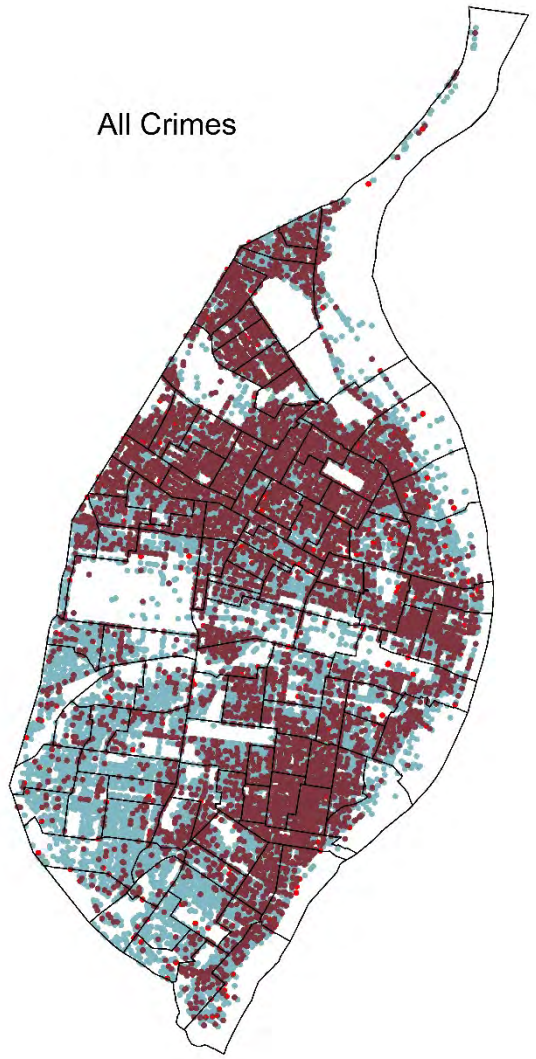


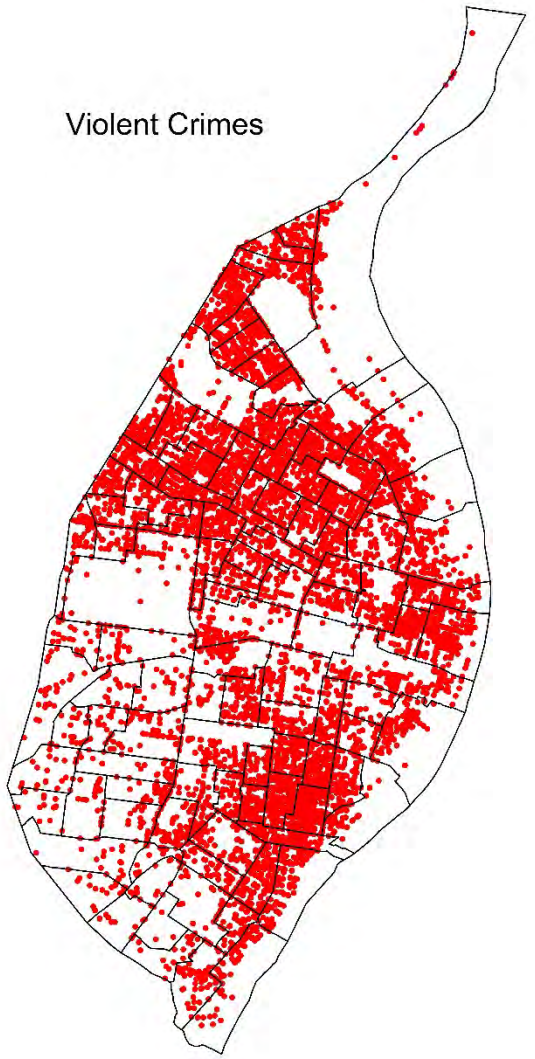




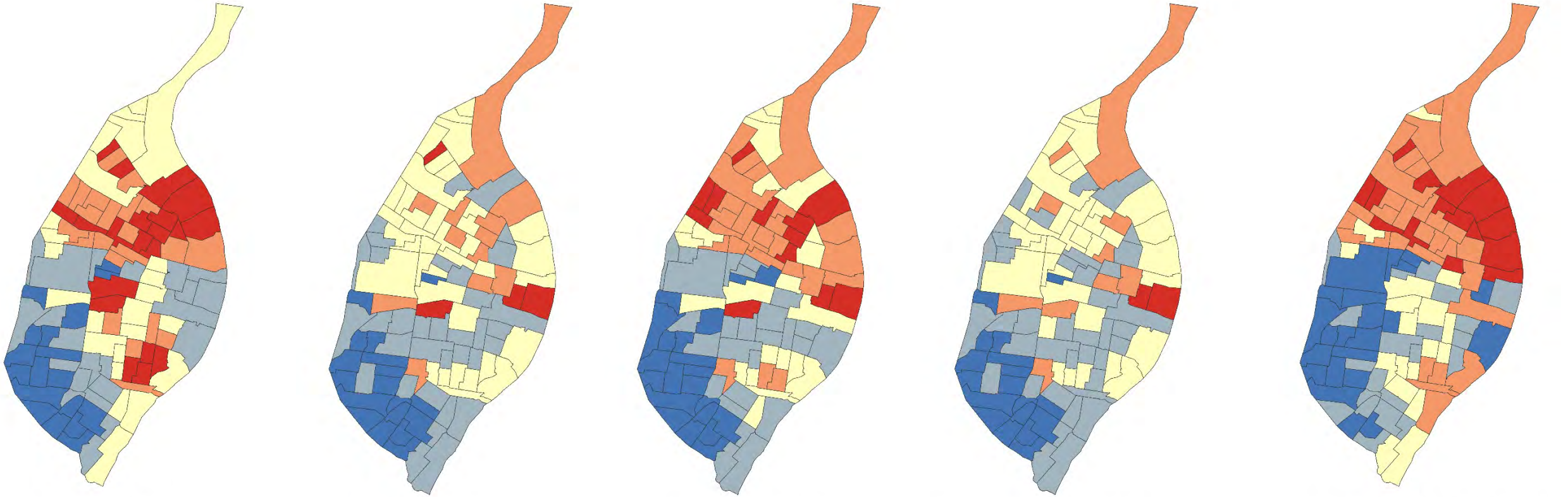
Geographic Distribution - Crimes







Aggregated Measures



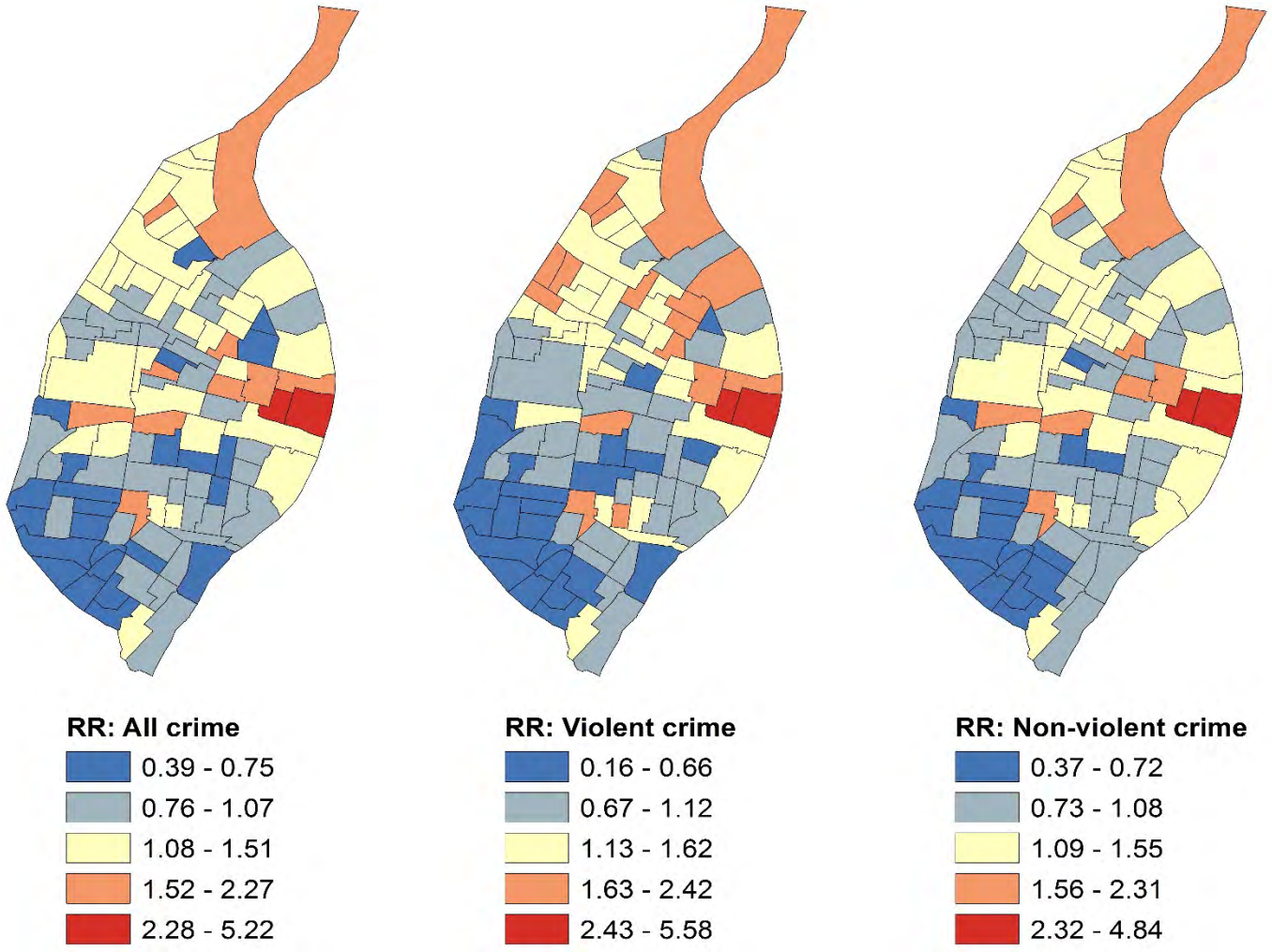
STAR Model Results

Table 2
Examining the intersection of aggregate blood lead levels and crime using spatial Poisson regression.

	Model 1	Model 2	Model 3
Panel 1: Violent crime	RR (95% CI)	RR (95% CI)	RR (95% CI)
BLL	15.36 (5.06, 40.90)	7.28 (2.49, 20.14)	6.57 (2.89, 17.18)
Concentrated dis.	–	1.20 (1.01, 1.41)	1.45 (1.05, 2.10)
Interaction term	–	–	0.66 (0.28, 1.41)
Panel 2: Non-violent crime	RR (95% CI)	RR (95% CI)	RR (95% CI)
BLL	2.90 (1.32, 8.28)	3.01 (1.42, 5.74)	3.19 (1.92, 5.92)
Concentrated dis.	–	0.94 (0.86, 1.03)	0.93 (0.73, 1.19)
Interaction term	–	–	0.87 (0.46, 1.69)
Panel 3: Total crime	RR (95% CI)	RR (95% CI)	RR (95% CI)
BLL	2.74 (1.83, 4.18)	5.02 (2.62, 11.90)	3.27 (1.89, 5.50)
Concentrated dis.	–	0.98 (0.92, 1.05)	1.06 (0.90, 1.28)
Interaction term	–	–	0.83 (0.49, 1.27)

BLL=blood lead level; RR=relative risk; CI=credible interval.

Smoothed RR map of crime in St. Louis, MO



What about lead exposure and STIs?

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Childhood lead exposure and sexually transmitted infections: New evidence

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Data

- Cases of gonorrhea & chlamydia during 2011 (Missouri DHSS)
- Condom vendors per tract (Shacham et al., 2015)
- Alcohol outlets per tract (State of Missouri Data Portal, 2008)
- Same lead data
- Same crime data
- Same concentrated disadvantage measure

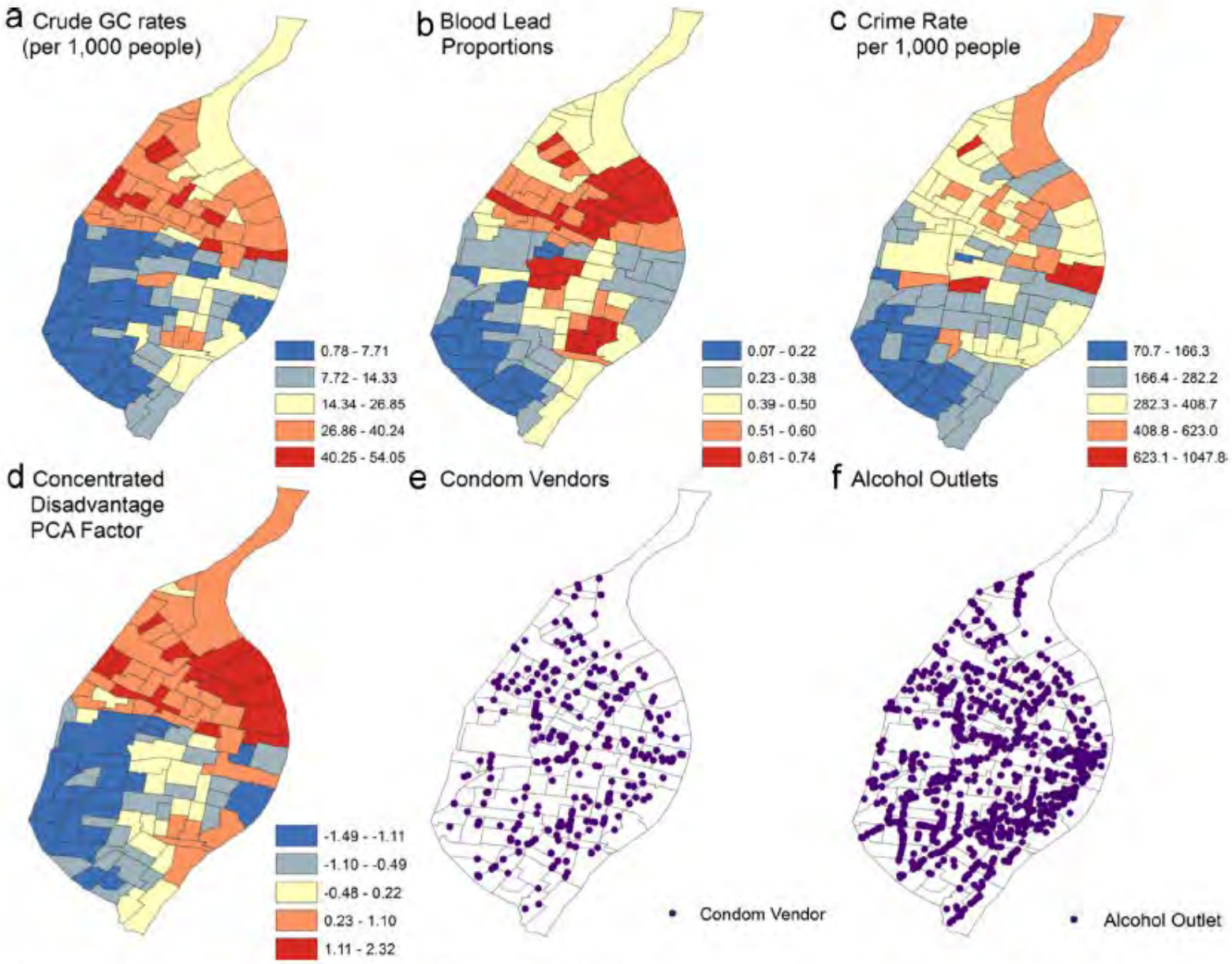


Fig. 1. Geographic distribution of gonorrhea and chlamydia, lead, and other confounders across census tracts in St. Louis City, Missouri.

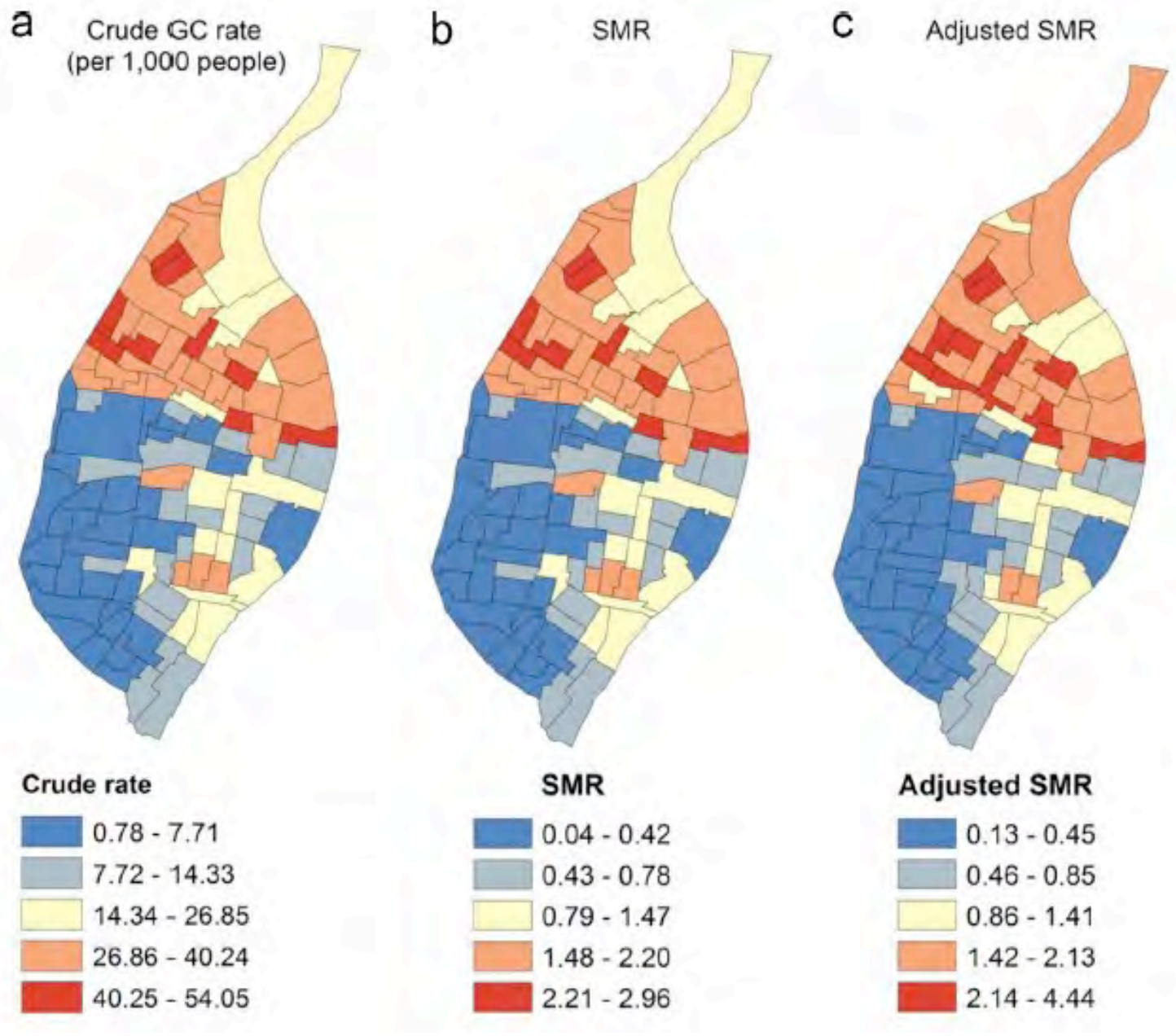
Table 3
Examining the association of gonorrhea/chlamydia and lead exposure using spatial poisson regression.

	Bivariate association	Multivariate association
	RR (95% CI)	RR (95% CI)
Proportion of elevated BLL tests, %	85.115 (65.105, 110.830)	6.404 (4.336, 9.526)
Total crime rate, *per 1000 people*	1.003 (1.003, 1.003)	1.001 (1.001, 1.002)
Alcohol outlets, *n*	0.989 (0.987, 0.992)	0.990 (0.986, 0.994)
Free condom locations, *n*	2.790 (2.230, 3.511)	1.080 (0.846, 1.370)
Median age of housing, *years*	0.992 (0.989, 0.994)	0.997 (0.993, 1.001)
Concentrated disadvantage, *Z*[a]	2.054 (1.981, 2.126)	1.545 (1.464, 1.628)

CI indicates credible interval.

[a] Z indicates a standardized index of concentrated disadvantage that was created using principal component analysis.

Note: Sparse sglmm model


a
Crude GC rate
(per 1,000 people)
b
SMR
c
Adjusted SMR
Crude rate
0.78 - 7.71
7.72 - 14.33
14.34 - 26.85
26.86 - 40.24
40.25 - 54.05
SMR
0.04 - 0.42
0.43 - 0.78
0.79 - 1.47
1.48 - 2.20
2.21 - 2.96
Adjusted SMR
0.13 - 0.45
0.46 - 0.85
0.86 - 1.41
1.42 - 2.13
2.14 - 4.44

Limitations

- Temporal mismatch of data
- Ecologic Fallacy
- Modifiable Area Unit Problem (MAUP)
- Causality?

Conclusions

- Lead exposure is bad – no matter how you slice it
- Lead exposure as a child may influence events much later in the life course
- Accounting for spatial structure is necessary when data are collected in spatial contexts
- It is time to include spatial info in ALL research studies
- Never been a more exciting time to do research

Thank You! Questions?